IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Attorney Docket No: 37697-0062

Applicant(s) Edward W. MERRILL *et al.* Confirmation No.: 5033

Serial No.: 10/197,263 Examiner: Susan BERMAN

Filing Date: July 18, 2002 Group Art Unit: 1711

Title: RADIATION AND MELT TREATED ULTRA HIGH MOLECULAR WEIGHT POLYETHYLENE PROSTHETIC DEVICES

DECLARATION OF ORHUN K. MURATOGLU

I, Orhun K. Muratoglu, do hereby declare as follows:

1. I have previously submitted declarations in the captioned application. In this declaration, I discuss (1) the differences between annealing (defined as not melting) and melting irradiated ultra high molecular weight polyethylene ("UHMWPE") and (2) the description and data provided by the inventors in their declaration previously filed pursuant to 37 CFR § 1.131.

Annealing versus Melting

2. In my declaration of October 5, 2004, I explained that annealing UHMWPE after it has been irradiated will not eliminate substantially all free radicals in the UHMWPE. By "annealing", I refer to heating UHMWPE to any temperature that is below the melting point. Heating to a temperature that is below the melting point, even to a temperature that is just short of the melting point, will allow crystalline lamellae to persist, which trap free radicals formed by the irradiation. Only when the melting temperature is crossed do all of the lamellae unfold, which allow the polyethylene chains travel freely such that free radicals can come within sufficient proximity to one another to recombine to form a covalent bond.

3. U.S. Patent No. 5,414,049 to Sun *et al.* ("the '049 patent") discloses annealing of irradiated polyethylene. The '049 patent explains that annealing should be performed at a temperature "between the room temperature and the melting point of the polymer." See column 5, lines 57-58. The '049 patent mentions 25°C to 140°C and preferably about 37°C to 135 °C, and more preferably 130°C. See column 5, lines 60-62. The '049 patent adds that a temperature selected for annealing should not exceed the distortion temperature of the plastic [UHMWPE] or the packaging

material for the plastic, and ultimately settles upon the temperature range of 37°C to 70°C. See column 7, lines 3-8.

4. Given the range of between room temperature and the melting point and avoidance of the distortion temperature, it is clear that the '049 patent directs the reader towards heating but not to the point of melting, and such heating should be sufficiently short of the melting point so as to avoid distortion. The temperature ranges involved here depend upon the melting temperature of the particular UHMWPE to be treated according to the "049 process. For example, some UHMWPE samples melt at 145°C, and therefore the use of an annealing temperature of 140°C would follow the teachings of the '049 patent. Other UHMWPE samples can have lower melting points, such as at 137°C. With lower melting point samples of UHMWPE, 140°C would be inappropriate but 130°C would be appropriate according to the teachings of the '049 patent.

5. Ultimately, the '049 patent seeks to reduce free radicals to an acceptable level, which is stated to be 1.0×10^{17} per gram of UHMWPE. See column 7, lines 36-39.

6. The invention presently claimed relies upon UHMWPE being brought above the melting point concurrent with or subsequent to irradiation. This invention reduces free radicals to the point that there are substantially no detectable free radicals in the UHMWPE as measured by electron spin/paramagnetic resonance according to the method of Jahan *et al., J. Biomed. Mat. Res.* 25: 1005 (1991). See page 14 of U.S. Serial No. 10/197,263.

7. The detection limit of current electron spin resonance technology is about 1 x 10^{14} free radicals per gram. Using this technology, I tested irradiated UHMWPE that had been annealed according to the '049 patent ("the '049 UHMWPE") at temperatures below the melting point of the UHMWPE (at 120°C or at 130°C) and irradiated UHMWPE that had been melted (at 170°C) concurrent with or after irradiation ("Merrill *et al.* UHMWPE") (see graph at Tab 1).

8. Irradiated UHMWPE samples were heated to 120°C or 130°C, which is below the melting point of the UHMWPE, and are referred to as "annealed samples." The Merrill *et al.* UHMWPE was heated to 170°C, which is above the melting point of all forms of UHMWPE.

9. The graph attached at Tab 1 shows that detectable free radicals are still in both annealed samples. On the other hand, the Merrill *et al.* UHMWPE, which is melted at 170°C after irradiation, shows substantially no detectable free radicals at the 1×10^{14} detection level. This means that the Merrill *et al.* UHMWPE will have no more than 1/1000th the level of free radicals that was considered acceptable according to the '049 patent. Accordingly, the Merrill *et al.* UHMWPE will have far fewer free radicals than samples annealed according to the '049 patent.

Therefore, annealing after irradiation, as disclosed in the '049 patent, results in materials having different properties than that attained by melting after irradiation, as in the instant claims.

<u>The Rule 131 Declaration</u>

10. I have reviewed the Rule 131 declaration of the inventors, where they describe the inventive acts relating to the melt irradiation ("MIR") and cold irradiation subsequent melting ("CISM") embodiments disclosed in the captioned application.

11. In Exhibit 1 of the Rule 131 declaration, the inventors stated the following at section (b):

> Crosslink as solid, melt, recrystallize: Irradiating the polymer as a solid will mean less cross-linking at the crystalline zones but higher cross-linking in the amorphous zones (more mobile chains can jump more to connect at different places). Melting & recrystallizing these will probably again lead to the original crystalline structure (though with reduced crystallinity) and selective segregation of cross-links into the amorphous regions. This is expected to be more wear resistant since molecules in the regions may be interconnected and crosslinked. Promises to be useful if (a) intercrystalline region slip is important during wear (b) if loss in hardness is not important.

This passage shows steps of irradiating and melting, which is ultimately followed by cooling, which allows for recrystallization in the context of a CISM methodology. As explained in the declaration, these steps were performed in the experiments that generated the data of Exhibit 4 of the Rule 131 declaration.

12. The data contained in Exhibit 4 of the declaration showed that the CISM approach use a Differential Scanning Calorimeter (DSC) for as a melting heat source resulted in the formation of cross-links and recrystallization. A Differential Scanning Calorimeter (DSC) is a device that contains a chamber to melt small samples of UHMWPE while taking precise measurements of the samples before, during and after the melting process.

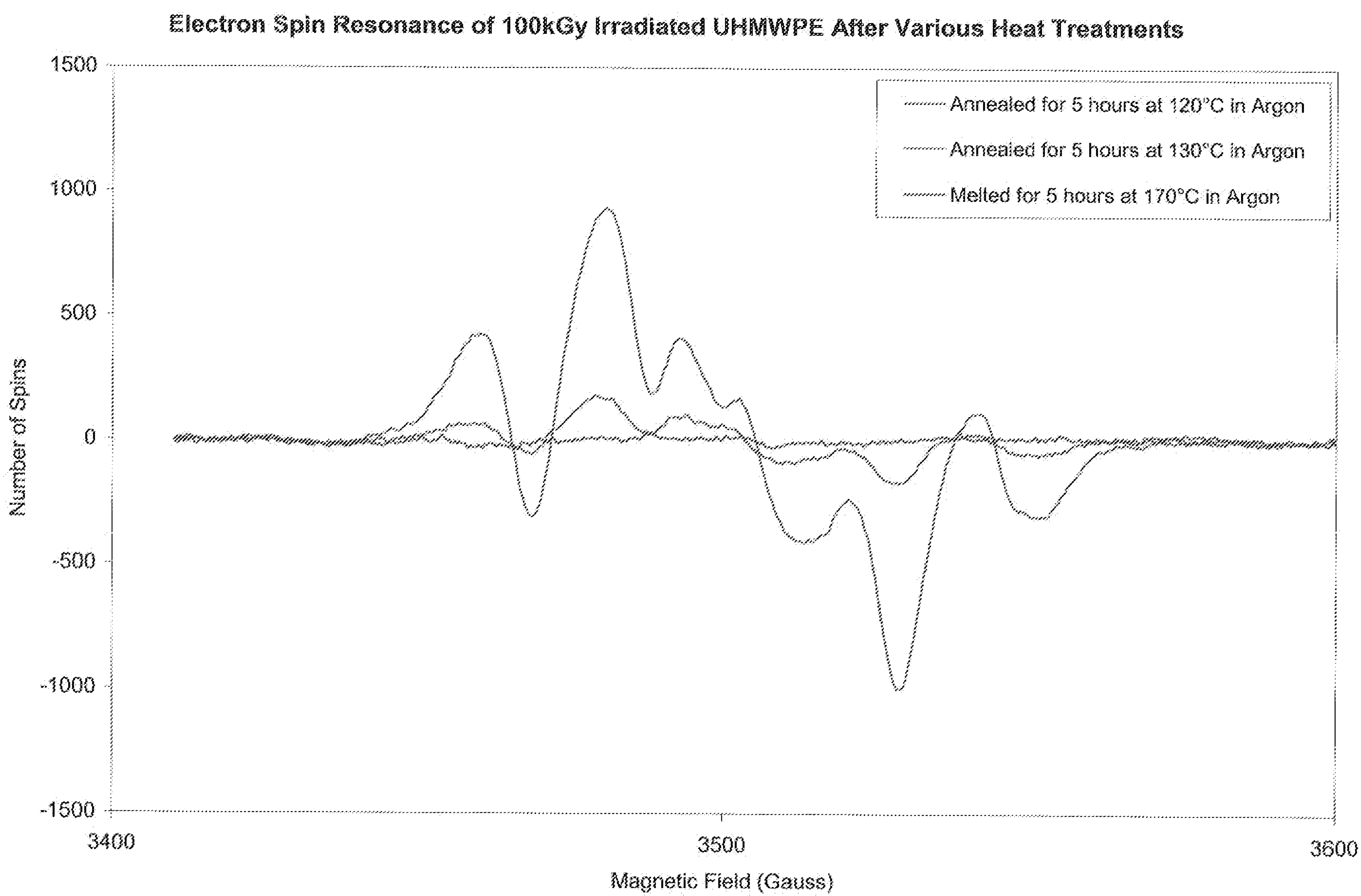
13. Practice of a CISM embodiment using a DSC for as a heat source for melting showed that crystallinity of 20 Mrad irradiated UHMWPE decreased to 41.69% from 54.71% (see data 4 in Exhibit 4), just as the inventors had predicted in Exhibit 1. This reduction in crystallinity is due to the formation of cross-links. Moreover, in the 20 Mrad sample, the average lamellae thickness went from a value of 1.61 to 0.978 microns (see data 4 in Exhibit 4), meaning that the UHMWPE kept its original crystalline lamellar structure, but with less of it as reflected by the lower overall crystallinity. The attainment and recordation of this data by the inventors was an immediate recognition that the approach they had previously described was workable and achieved the results they had earlier predicted.

14. Nothing more was needed from the inventors to show that the CISM method would yield a material as predicted that would be suitable for its intended purpose. The data show that the inventors had actually reduced to practice UHMWPE crystallinity through irradiation-created cross links, which were sufficiently present and strong so as to prevent original crystallinity from being restored, which would occur in the absence of irradiation-created cross-links.

15. I declare further that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements and the like are made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of this application or any patent issuing thereon.

5/19/05
Date

Orhun K. Muratoglu, Ph. D.


Electron Spin Resonance of 100kGy Irradiated UHMWPE After Various Heat Treatments
Annealed for 5 hours at 120°C in Argon
Annealed for 5 hours at 130°C in Argon
Melted for 5 hours at 170°C in Argon
1500
1000
500
0
-500
-1000
-1500
Number of Spins
3400
3500
3600
Magnetic Field (Gauss)